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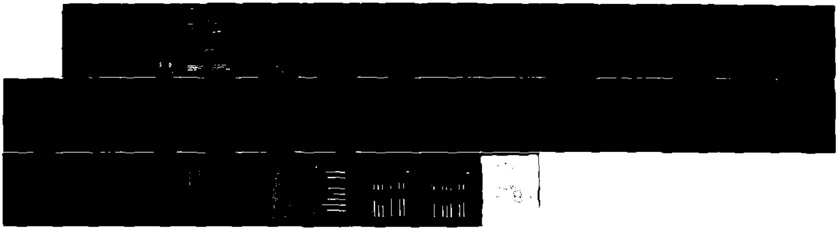

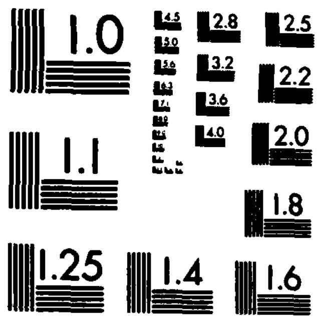

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OPERATION EVEREST II: NUTRITION AND BODY COMPOSITION

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Progressive body weight loss occurs during high mountain expeditions, but whether it is due to hypoxia, inadequate diet, malabsorption, or to multiple stresses of the harsh environment is unknown. To determine whether hypoxia alone causes such weight loss, six men, provided with a palatable ad libitum diet, were studied during progressive decompression to 240 Torr for 40 days in a hypobaric chamber where hypoxia was the major variable. Caloric intake decreased 42.3% from 3136 kcal to 1789 kcal. The percent carbohydrate in the diet decreased from 62.1% to 53.2% ($p<0.001$). All subjects lost weight averaging about 7.4 ± 2.2 kg (Mean$\pm$SD). Hydrostatic weighing indicated that 4 subjects lost 2.7% body fat whereas two gained 0.65%. Computerized tomographic scans indicated that most of the weight loss was derived from lean body mass. Data indicated that prolonged exposure to increasing hypoxia is associated with a reduction in carbohydrate preference and body weight despite access to ample varieties and quantities of food. This study suggested that hypobaric hypoxia rather than the combined stress of the mountain environment is sufficient cause for the deteriorations in food consumption reported by mountain expeditions at high altitude.

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ABSTRACT

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Keywords: Acclimatization, High Altitude, Nutrition, Food Intake, ~~Weight Loss~~, Body Composition.

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INTRODUCTION

Loss of body weight is common during exposure to high altitude (1-7). Acute mountain sickness (AMS) is common after rapid ascent to moderate altitude and may contribute to weight loss due to anorexia, nausea or vomiting, and dehydration. Altitude sickness is dependent on elevation, rate of ascent, and acclimatization but usually decreases after the first three days (8-11). Appetite suppression may decrease caloric and protein intake by as much as 30% and 40% respectively (1,3,5,6,12) and thus may explain the body weight loss which persists after AMS symptoms have subsided. Altitude studies observing continuous body weight loss are numerous and contradictory and have attributed weight loss to reduced caloric intake resulting from anorexia (1,3-7); loss of stored body fat (3,6,13); loss of body fluid (1,2,3,6,13-17); malabsorption of ingested fat and/or carbohydrate (CHO) especially at altitudes in excess of 4300 m (2,18,19); and an elevated rate of energy expenditure under basal, resting, and mild to moderate exercise conditions (2,9-11,20-24). Body weight loss ranging from 3-5.4% (3,6,25,26) with rates of 145-330 g/day have been reported (6,27,28). Although loss in body weight at altitude is common, the composition of the weight loss is unclear. Some investigations show a reduction in body fat (3,6,9,13,27,29), while others show losses in lean body weight (1,30).

There is a paucity of reports and a conflict of views regarding CHO preference at altitude. Anecdotal evidence from climbers suggests that they prefer sweets at altitude (7,12,16,26,27). However, researchers have

suggested that the preference for carbohydrate may be due to a greater availability and ease of preparation of CHO containing foods (12,27). Few studies have determined dietary preferences for carbohydrate at high altitudes when subjects are given a variety of palatable foods *ad libitum* (23).

The purpose of the present study was to determine if dietary preferences changed, if body weight could be maintained by offering palatable foods *ad libitum*, and which body compartments contributed to body weight loss during a simulated ascent of Mount Everest (240 Torr or 29,000 feet).

METHODS

Nine subjects in excellent physical condition were selected to participate in this study. One subject was excluded at the beginning of the study because of an upper respiratory infection and one subject each were withdrawn at 18,000 and 25,000 feet. The subjects are described by Houston (31). The subjects were confined in a hypobaric chamber for 40 days during progressive decompression to 240 Torr to simulate previously successful ascents of Mount Everest. Due to missing data on the first and last days of exposure to altitude, complete dietary data were available for the 6 subjects for only 38 days. The data were divided into 7-day periods except for the last period which only included data for 3 days (Figure 1).

The subjects were allowed access to any quantity and variety of palatable food. The menus, food preparation, and dietary data collection were under the supervision of a registered dietitian. The subjects selected three meals per day from menus consisting of approximately 3000 kcal/day distributed to provide 60% carbohydrate (%CHO), 15% protein (%PRO), 25% fat (%FAT) in the diet. The menus included a full breakfast selection, soup and/or sandwich lunches, commercial and home-cooked dinners, and food accompaniments to balance meals. The foods were weighed before being served to the subjects. The returned foods were weighed and this amount subtracted from the amount served.

A variety of foods were available in the chamber for between meal snacking. Assorted fluids were available <u>ad libitum</u> and subjects were encouraged to drink to prevent dehydration. The subjects recorded any foods

and fluids that were ingested between the three meals. The food and fluid intakes were analyzed using the University of Massachusetts Nutrient Data Bank program.

Energy expenditure could not be measured; therefore, the Harris Benedict formula (32) was used to estimate basal energy expenditure (BEE). Because the subjects were confined in a small space only 20% of BEE was added for routine activities. Since the subjects were keeping a daily log of their exercises, the calories expended from these exercises were added to the BEE + 20%BEE value. The energy expenditure values were not adjusted for possible changes in rate of energy expenditure due to altitude.

The subjects were weighed daily on a physician's scale calibrated to the nearest 1/4 pound. Body heights (cm) were taken at the beginning of the study. Body composition information was collected at sea level pre- and post-altitude exposure. Whole body density (hydrostatic weighing), residual lung volume, and anthropometric measurements were obtained preprandial 3 to 6 days prior to the start of the study and within 20 hours after return to sea-level from altitude. During the hydrostatic weighings, a minimum of six practice trials were performed before three actual readings were recorded to assure a true baseline. Residual volumes were obtained while the subjects were underwater during the each of the last three readings. Body density was converted to percent body fat (%BF) using the Siri formula (33).

Anthropometric measurements were obtained before noon on each of the measurement days by the same investigator throughout the entire study. Subjects were encouraged to exercise during the study but not before the anthropometric measurements. Seven skinfold and 10 soft tissue

circumference measurements were obtained while subjects were standing. Two non-consecutive measurements were obtained at each site. A third measurement was taken if the difference between the first two was greater than 1%. The mean of the two or three measurements was used in the statistical analysis. Skinfolds were obtained on the right side of the body (triceps, scapula, chest, midaxillary, suprailiac, abdomen, and thigh) using a Harpenden skinfold caliper with a caliper pressure of 10 g/mm^2. Circumferences of the neck, shoulders, chest, hips, thigh, calf, upper arm, forearm, and two abdominal sites were measured using a Gulick spring-loaded tape. The measurement sites were located using standard landmarks.

To quantitatively assess the pattern of fat and muscle distribution (34), computerized tomographic (CT) scans were taken of the upper arms and thighs at sea level, pre- and post-altitude exposure. Five 1-cm thick slices were scanned in each limb. In the thigh the center slice was positioned on a mark at mid-point between the tibial tubercle and the anterior superior iliac crest; i.e. mid thigh. In the arm the center slice was positioned on a mark 60% of the distance down from the acromium to the medial condyle of the ulnar to sample the thickest part of the upper arm. The area of the bone, muscle, and fat on each slice was measured with a planimeter interfaced to an IBM computer. To allow for possible changes in the CT scanner magnification between the pre- and post-hypoxia images, the fat and muscle content of each slice was expressed as a ratio of fat to bone (fat/bone) and muscle to bone (muscle/bone). It was assumed that there would be no significant change in the diameter of the ulna or femur in the 42 days between measurements. The data from the 10 slices in both limbs were pooled in each individual.

STATISTICS

Analysis of variance was used to test for significant differences between the different periods of the study. The Student Newman Keuls' post hoc test was used to determine where the differences occurred. Regression analysis was applied to the mean body weights to determine if the slope of the line was significantly different from zero. The data are reported as mean$\pm$SD. Data for the 2 subjects (#5 & #7) who were withdrawn from the study were included in the charts but were not included in the means. Correlation analysis was used to study the relationships between energy and the carbohydrate, protein, and fat components of the diet.

RESULTS

The physical characteristics of the subjects on the first day for which complete dietary data were available (day 2) are described in Table 1. The mean nutrient intake met the Recommended Dietary Allowances (RDA) (35) for all vitamins and minerals. Five of the subjects had mean protein intakes that exceeded the RDA of 0.8 g/kg body weight but the sixth subject had a mean protein intake which was 83.0% of his protein needs. The caloric intake decreased over the 38 days at altitude averaging 2639±848 kcal/day (Mean±SD) (Table 2). Caloric intake during period 1 averaged about 3136±557 kcal/day and gradually decreased to 1789±682 kcal/day during period 6. The percent decrease in energy intake between Periods 1 and 6 was 42.3%. Two subjects were able to limit the percent decrease in calories to 28.2 and 23.3%, respectively.

The subjects lost 8.9±2.0% of their sea-level body weights (Table 3, Figure 2). Mean body weight loss for the 38 days was 7.4±2.2 kg ($p<0.01$). Body weight was lost at a mean rate of 196 g/day (range 110.5 - 260.5 g/day). Regression analysis showed that the decrease in weight as the altitude increased was significantly different from zero (slope=-0.16, $p<0.001$). All of the subjects lost more weight than would be expected from comparisons of caloric intake to energy expenditure. Fluid balance data showed that the subjects were not dehydrated (Table 4).

According to the hydrostatic weighing measurements, there was an overall 1.6% decrease in %BF pre- to post-exposure to altitude but the difference was not significant. Four subjects lost an average of 2.7 %BF while the

other 2 subjects gained an average of 0.65 %BF (Figure 3). Mean energy expenditure was greater than energy intake for the 4 subjects whose %BF decreased (Table 3). The 2 subjects that gained %BF were consuming sufficient calories so that they should have gained instead of losing body weight. Calculations of the fat component of body weight (kg) and lean body mass (LBM) showed a consistent decrease for all subjects. Circumference measurements significantly decreased ($p<0.05$) in the arms and thighs of all subjects (Table 5). The sum of all 7 skinfold measurements followed the same trend as hydrostatic weighing with skinfolds decreasing for 4 subjects and increasing for 2 subjects (Table 6). The CT scan fat/bone data (Figures 4 and 5) showed the same trends as the hydrostatic weighing and skinfold data. Circumference, %BF by hydrostatic weighing, skinfold, and CT scan data showed that body fat decreased except for the 2 subjects.

Muscle mass decreased (Figures 4 and 5) in all subjects. CT scan muscle/bone measurements showed that the difference was not significant in the arm ($p<0.073$) but was significant ($p<0.01$) in the thigh measurement. The changes in the thigh measurements may have been significant because of its larger muscle mass. Since bone measurements were not expected to change, changes in the ratio were probably due to a change in muscle mass.

During the first 7 days of exposure to altitude the subjects consumed a higher percentage of total calories as carbohydrate (62.1% CHO); but as the altitude increased to 29,000 feet, the %CHO decreased to 53.2% (Table 7). There was a significant difference ($p<0.001$) between period 1 and all the following periods. As the %CHO decreased, the %FAT increased ($r=-0.90$, $p<0.001$).

DISCUSSION

The data on energy intake showed a downward trend with increasing hypoxic exposure. The average decrease in-caloric intake of 42.3% was comparable to the 20-40% range found in the literature for mountain sojourns up to 26 days duration (3,5,12). Four of the subjects decreased their caloric intake by 50% while 2 subjects were able to maintain a caloric intake of 71.8 and 76.7% of their intake during period 1. These 2 subjects started the study eating less than their energy requirements whereas the other 4 subjects ate more than their energy requirements (36). Boyer and Blume (27) reported that some climbers overeat before starting a mountain expedition to minimize the anticipated anorexia and body weight loss. The two subjects who did not overeat at the beginning of the study appeared to make an effort to maintain their initial energy intake. The weight losses for these 2 subjects were high at 11.6 and 9.7%. Greater energy expenditures during exposure to altitude than those of the other 4 subjects probably account for some of the large weight losses. However the amount of weight lost was greater than expected when comparing energy intake to energy requirements. Energy requirements have been shown to increase with heavy exercise at altitude compared to that at sea-level (22). An unexpected increase in energy expenditure coupled with decreased energy intake at altitude may have caused energy deficits which led to the catabolism of body protein and/or fat (1,3,6,12,13,24).

On an actual mountain expedition, it is difficult to determine whether body weight loss is due to increased energy expended in hard physical work,

the cold environment, limited availability or palatability of food, dehydration, malabsorption, AMS, or combinations of these stresses. Altitude sickness is affected by altitude, speed of ascent, and length of stay. The longer the stay at altitudes up to 18-20,000 feet, the better the acclimatization. However, caloric intake and body weight tend to continuously decrease during long stays at altitudes greater than 16,000 feet (2,12). In the present study the subjects were allowed to acclimate for 3-day periods at 15,000, 18,000, 20,000, and 25,000 feet. They tended to feel better after each of the three day acclimatization periods (31), but nevertheless all subjects lost body weight continuously throughout the study. Body weight loss was not due to increased physical activity, the cold environment, or to limited food availability. The amount of exercise actually decreased for most of the subjects after reaching 23,000 feet on day 26. These results suggested that deterioration in physical condition could override the effects of acclimatization as Pugh (2) and Blume (12) had suggested as early as 1962. The 8.9% weight loss in the present study is greater than previously reported for actual field measurements. Studies have shown weight losses of 3-3.49% in 8 days at 4300 m (3,25); 5.4% in 12 days at 4300 m (6); and 5% in 5 weeks of exposure at 4000-7000 m (26). Although the subjects were provided palatable food <u>ad libitum</u> and were not exposed to excessive exercise, they were not able to slow down or prevent continuous weight losses that were greater than previously reported. This suggests that hypobaric hypoxia rather than the combined stresses of the mountain environment is a sufficient cause for the deterioration reported by major mountain expeditions.

The mean energy intake for 4 subjects was less than their calculated energy requirements but the other 2 subjects ingested more calories than were needed to meet their energy expenditure and should have gained body weight. However, all 6 subjects lost body weight and the loss was greater than expected. The reason for this loss is unknown although the subjects with caloric intakes greater than their energy requirements did tend to have smaller body weight losses. We can only speculate on the causes of the unexpectedly large weight losses. Researchers have suggested that body weight loss may be due to water loss; increased metabolic rates; and fat and/or carbohydrate malabsorption (2,27). Hypohydration may be due to decreased fluid intake (1); increased water loss (2,6,14); and loss of fluid from the lungs due to hyperventilation (15,16). However, other studies have shown that normal body hydration can be maintained when body weight is decreasing (3,13,17). The fluid data for the present study showed that the subjects were able to maintain hydration. Fluid intake exceeded the output by several hundred milliliters but the water loss due to hyperventilation and sweating would probably account for the difference in fluid balance. Excessive sweating might have caused a negative fluid balance but the temperature was maintained at about 70°F with about 60-80% humidity and the mean energy expenditure from exercise was about 715±807 kcal/day (36).

Several researchers have suggested that energy expenditure increases at altitude (9,10,22). The effects of altitude on basal (2,9,22), resting (20,21), and mild to moderate exercise (21,22) conditions have been studied and show an increase of 7-11% of energy expenditure at altitude. The increase in energy expenditure has been attributed to the increased work of

respiration and/or the decreased efficiency of work performance. However, data from other studies show normal basal metabolic rates up to 3475 m (11), that the increase in basal energy expenditure is transient and returns to normal after about a week of acclimatization at 4300 m (37), and after 4 months at 5790 m (2). Increased energy expenditure/metabolic rates could account for the body weight losses but was not studied.

The possibility that malabsorption due to hypoxia is a cause of weight loss has been debated (2,18,19,27) but was not investigated in this study. Rai et al. (18) and Sridharan (19) showed no disturbance in digestibility and utilization of dietary fat and/or carbohydrate up to 4700 m. Other studies have reported malabsorption of fat and/or xylose (2,27) at higher altitudes.

The confinement of the subjects in a hypobaric chamber could have affected body weight loss. Loss of appetite, body weight, and strength could be attributed to confinement in a small space, isolation from the real world, limited physical activity, and boredom as was experienced in this study. However evidence is not available on the interaction of these factors with body weight and appetite loss. A study of submariners showed weight loss in 52% of the crews during long confinements however the authors speculated that a third of the sailors may have been actively dieting (38). The work on confinement of astronauts is not applicable to this study because the effects of weightlessness cannot be separated from the effects of confinement.

There was a mean overall decrease in body weight, %BF, body fat weight, and LBM. In 2 subjects the %BF measurements as indicated by hydrostatic

weighing, skinfold measurements, and CT scanning increased. The fact that these 2 subjects ate more calories than they needed for energy expenditure and reduced their exercise levels suggests the possibility that their subcutaneous fat was maintained or increased slightly. In general, the present study confirmed the results of previous studies that showed losses in skinfold thickness and %BF (3,6,9,13,29) however, there was a wide range from the 2 subjects with increases in skinfold measurements and %BF to losses up to 33% in skinfold thickness. Fulco (30) reported an increase in %BF after an 18-day exposure to 4300 m in a hypobaric chamber, however, the increase in %BF was attributed to the loss of body weight (30). In the present study the weight of the fat component and the body weight decreased for both subjects whose %BF increased. Skinfold measurements increased to support the increase in %BF. Mountain climbing expeditions have never reported increases in %BF. The difference is probably due to the fact that the subjects in the hypobaric chamber were not exercising as much or in the same manner as would occur during an actual assault on a mountain.

About 25.8% of the weight loss was from fat and 74.2% from the LBM. Averaging in the values for the 2 subjects that gained %BF decreased the percent of weight loss attributable to fat. Since the subjects were not dehydrated, much of the loss in LBM was from muscle mass.

The %BF measurements, skinfold and circumference measurements, and the CT scans presented an integrated picture of the changes in body composition. The overall trend was a reduction in LBM and decreasing body fat except for 2 subjects who seemed to have gained fat even though they lost body weight.

Several studies have shown that subjects prefer carbohydrate at high altitude, usually at the expense of fat (2,10,23). Others (12,27) have found intakes of carbohydrate to increase from 42-55% at sea-level to 52-63% at altitude. However, Consolazio et al. (23) showed that the preference for carbohydrate occurred only during the first week at altitude and decreased during prolonged exposure and the present study confirmed his findings. Though a high carbohydrate (60%) diet was offered, subjects significantly decreased their carbohydrate intake after the first period when given a free choice of food. In the present study, a wide variety of appetizing foods was readily available to the subjects, and they consumed a relatively balanced diet. In 1969, Kryzwicki et al. (6) observed similar body weight losses whether the subjects consumed a high carbohydrate (68%) or a low (42%) carbohydrate diet during 12 days at 4300 m; therefore, increased dietary carbohydrate intake did not decrease body weight loss. Consolazio et al. (10) reported that a high carbohydrate diet increased work performance at the highest of four work levels after a rapid ascent to altitude. Carbohydrate may increase the respiratory quotient to improve metabolic efficiency and decrease the physiological altitude by 1-2000 feet (39-41) but the subjects in the present study voluntarily decreased their intake of carbohydrate when they started with a high carbohydrate diet.

CONCLUSION

Conclusions from this study were: (1) total energy requirements decreased as altitude increased; (2) caloric intake decreased as altitude increased; (3) fluid balance indicated little or no dehydration or edema; (4) intake of essential vitamins and minerals and protein was not deficient except for protein for one subject; (5) lack of oxygen, lack of adequate exercise, and confinement may have caused anorexia which contributed to continued body weight loss; (6) the amount of body weight actually lost can not be accounted for when balancing caloric intake with energy expenditure, malabsorption or increased energy expenditure may have contributed to the unexpectedly large losses; (7) %BF decreased in 4 subjects but increased in 2 subjects whose caloric intake indicated that they should have gained weight; (8) body fat weight decreased in all subjects; and (9) muscle mass accounted for most of the decrease in LBM.

The data indicate that prolonged exposure to increasing hypoxia does not increase or maintain a high carbohydrate preference and that body weight was not maintained despite provision of a highly palatable *ad libitum* diet. It is concluded that hypoxia per se could account for the weight loss observed on high mountain treks.

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TABLE 1

Physical characteristics of subjects*

Variables	Mean ± SD	Minimum	Maximum
Age, years	27.5 ± 2.2	25.0	31.0
Height, cm	184.0 ± 10.3	171.4	196.8
Weight, kg	82.97 ± 9.78	74.09	100.91

*Excluding subjects #5 & #7

TABLE 2

Energy intake (kcal/day) during 40 days of progressive decompression to 240 Torr

Subject Number	Period							Decrease in Caloric Intake (%)
	1	2	3	4	5	6	Mean	
1	3570	2874	2658	2450	1643	1332	2536	62.7
3	2864	2662	2447	1934	1289	1137	2152	60.3
4	2650	2833	2712	2658	2634	1903	2635	28.2
5	3252	2867	2499	2516	1868	--	2695	42.6
6	3107	3108	3112	2136	2471	2383	2755	23.3
7	2672	2024	--	--	--	--	2373	24.3
8	3447	3533	3353	2615	2695	1773	3022	48.6
9	3178	2935	2861	2191	2742	2206	2736	30.6
Mean*	3136†	2991†	2857†	2331	2246	1789‡	2639	42.3
SD	557	664	788	804	874	682	848	17.2

*Excluding Subjects 5 & 7
†Significantly different from other periods
‡Significantly different from periods 4 & 5
$p < 0.001$

TABLE 3
Energy balance and weight change with increasing exposure to altitude for 38 days

Subject Number	Energy Requirement (kcal)	Energy Intake (kcal)	Change in Body Weight Expected (kg)	Actual (kg)	Loss (%)
1*	2993	2536	-2.3	-9.9	9.8
3*	2421	2152	-1.3	-6.1	8.0
4*	4391	2635	-8.7	-9.8	11.6
5†	2386	2695	+2.7	-1.7	2.9
6*	3355	2755	-3.0	-8.2	9.7
7‡	3017	2373	-2.4	-3.0	4.1
8*	2775	3022	+1.2	-6.5	8.4
9*	2372	2736	+4.0	-4.2	5.7
Mean	3051	2639	-1.7	-7.4	8.9
SD	752	289	4.3	2.2	2.0

*October 7 to November 13, 1985
†October 7 to November 7, 1985
‡October 7 to October 19, 1985

TABLE 4
Mean fluid balance for 38 days of exposure to increasing altitude

Subject Number	Fluid Balance (ml/day)
1	583
3	72
4	314
5	251
6	196
7	252
8	496
9	121
Mean*	296
SD	1260

*Excluding subjects 5 & 7

TABLE 5
Circumference measurements (cm) Pre- and Post-exposure to 40 Days of Progressive Decompression to 240 Torr

Site	Time	#1	#3	#4	#5*	#6	#7†	#8	#9
Triceps	Pre	31.9	28.2	27.9	26.9	29.4	28.0	30.0	30.9
	Post	29.8	26.3	25.8	25.7	27.3	-	28.8	28.3
Thigh	Pre	62.5	54.7	58.7	49.0	57.0	57.5	59.0	57.1
	Post	57.7	51.4	52.1	46.2	51.8	-	55.0	53.8

*Withdrawn from study on day 33
†Withdrawn from study on day 16

TABLE 6
Skinfold measurements (mm) pre- and post-exposure to 40 days of progressive decompression to 240 Torr

Site	Time	#1	#3	#4	#5*	#6	#7†	#8	#9
Triceps	Pre	9.8	9.9	9.7	7.9	7.0	7.9	8.6	8.8
	Post	9.1	9.2	7.9	7.3	5.7	-	8.8	8.2
Subscapular	Pre	11.7	13.8	7.7	6.3	11.0	7.9	7.5	8.7
	Post	11.1	12.8	6.5	6.3	9.3	-	7.8	11.2
Chest	Pre	6.3	6.3	4.2	3.8	4.4	4.9	4.4	5.9
	Post	6.1	6.5	4.2	4.4	3.9	-	5.9	5.7
Midaxillary	Pre	9.3	12.8	5.1	4.7	6.1	5.0	8.2	10.1
	Post	7.5	9.5	3.8	4.6	4.6	-	7.4	10.2
Suprailiac	Pre	13.9	22.7	12.2	5.9	8.5	12.7	8.4	14.3
	Post	12.5	18.4	6.1	6.5	6.9	-	12.9	13.8
Abdominal	Pre	22.9	21.1	10.5	7.1	8.7	11.5	8.0	20.7
	Post	19.8	17.4	9.4	8.2	6.4	-	13.5	23.1
Thigh	Pre	12.5	18.0	15.5	7.3	9.6	8.0	12.4	12.4
	Post	12.3	16.1	11.1	9.0	7.3	-	14.1	12.7
TOTAL	Pre	86.4	104.6	64.9	43.0	55.3	57.9	57.5	80.9
	Post	78.4	89.9	49.0	46.3	44.1	-	70.4	84.9

*Withdrawn from study on day 33
†Withdrawn on day 16

TABLE 7
Percent of dietary calories from carbohydrates

Subject Number	Period 1	2	3	4	5	6	Mean
1	61.8	50.8	54.5	55.7	51.6	54.3	54.9
3	62.6	54.4	54.5	52.8	56.4	54.5	56.1
4	67.5	64.6	55.4	57.2	59.0	50.6	59.9
5	63.3	58.0	59.1	60.4	61.1		60.3
6	68.0	54.3	55.4	52.3	54.4	51.2	57.0
7	59.7	51.2					55.8
8	54.0	47.9	47.4	43.5	37.3	55.0	46.8
9	58.5	49.9	56.2	53.6	45.0	53.4	52.5
Mean*	62.1†	54.5	53.2	52.9	50.6	53.2	54.5
SD	7.1	9.0	9.1	9.6	10.5	7.0	9.6

*Excluding subjects 5 & 7
†Significantly different, $p < 0.001$

FIGURE 1. ASCENT PROFILE BY AMBIENT PRESSURE AND ALTITUDE WITH EXPOSURE DAYS DIVIDED INTO PERIODS

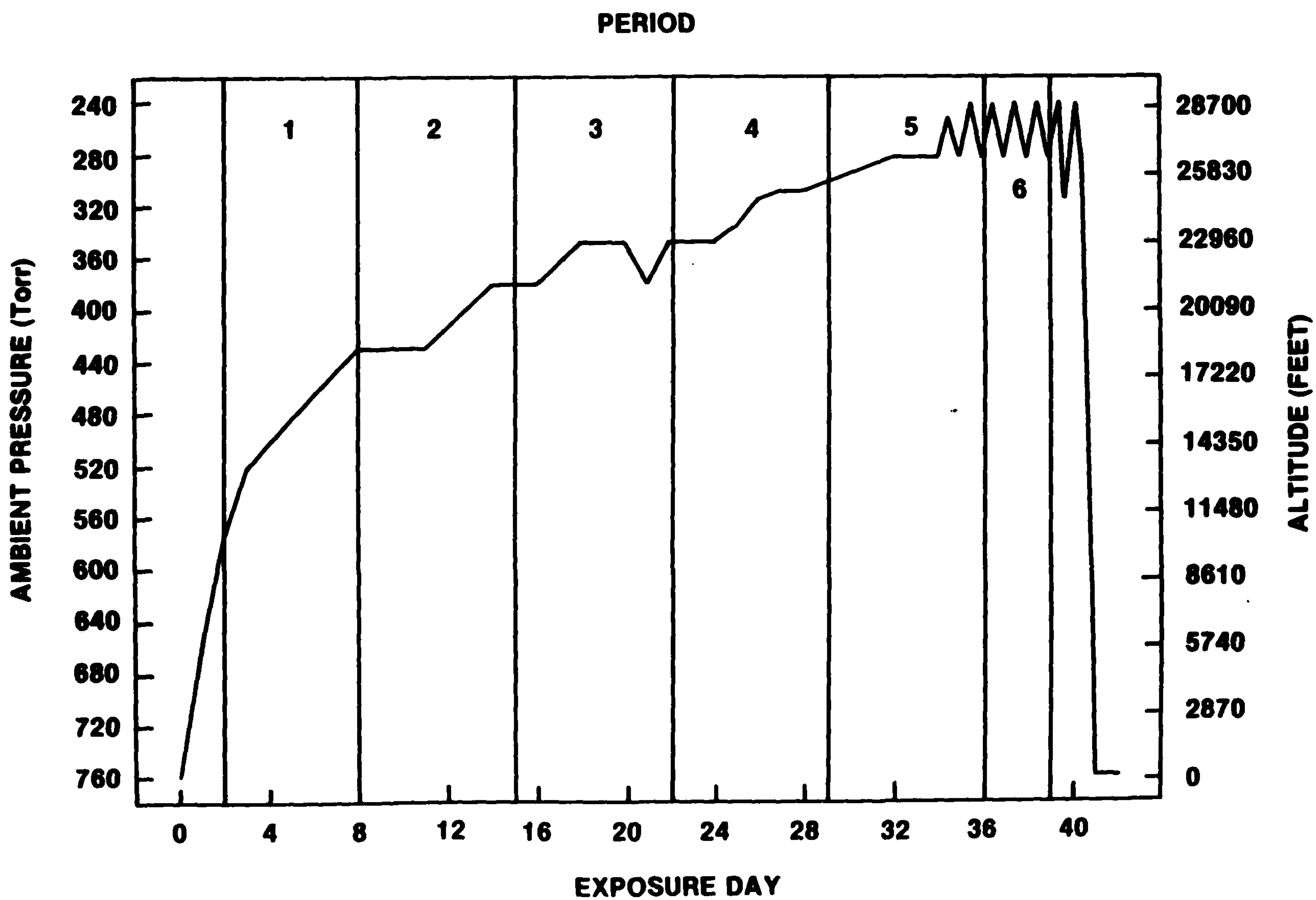

Figure 2
MEAN ENERGY and WEIGHT MEASUREMENTS

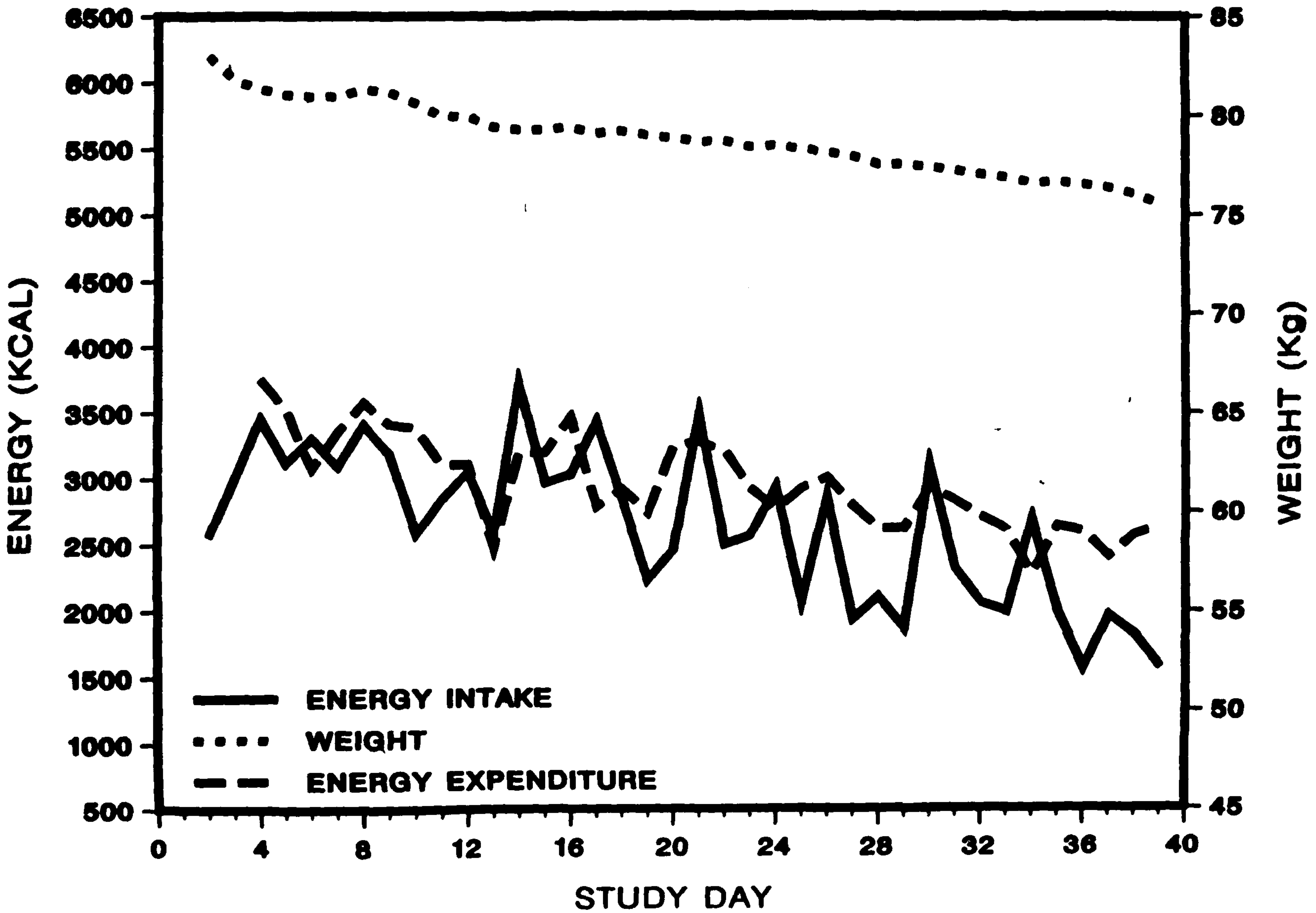

Figure 3

BODY COMPOSITION CHANGES

PERCENT BODY FAT BY HYDROSTATIC WEIGHING

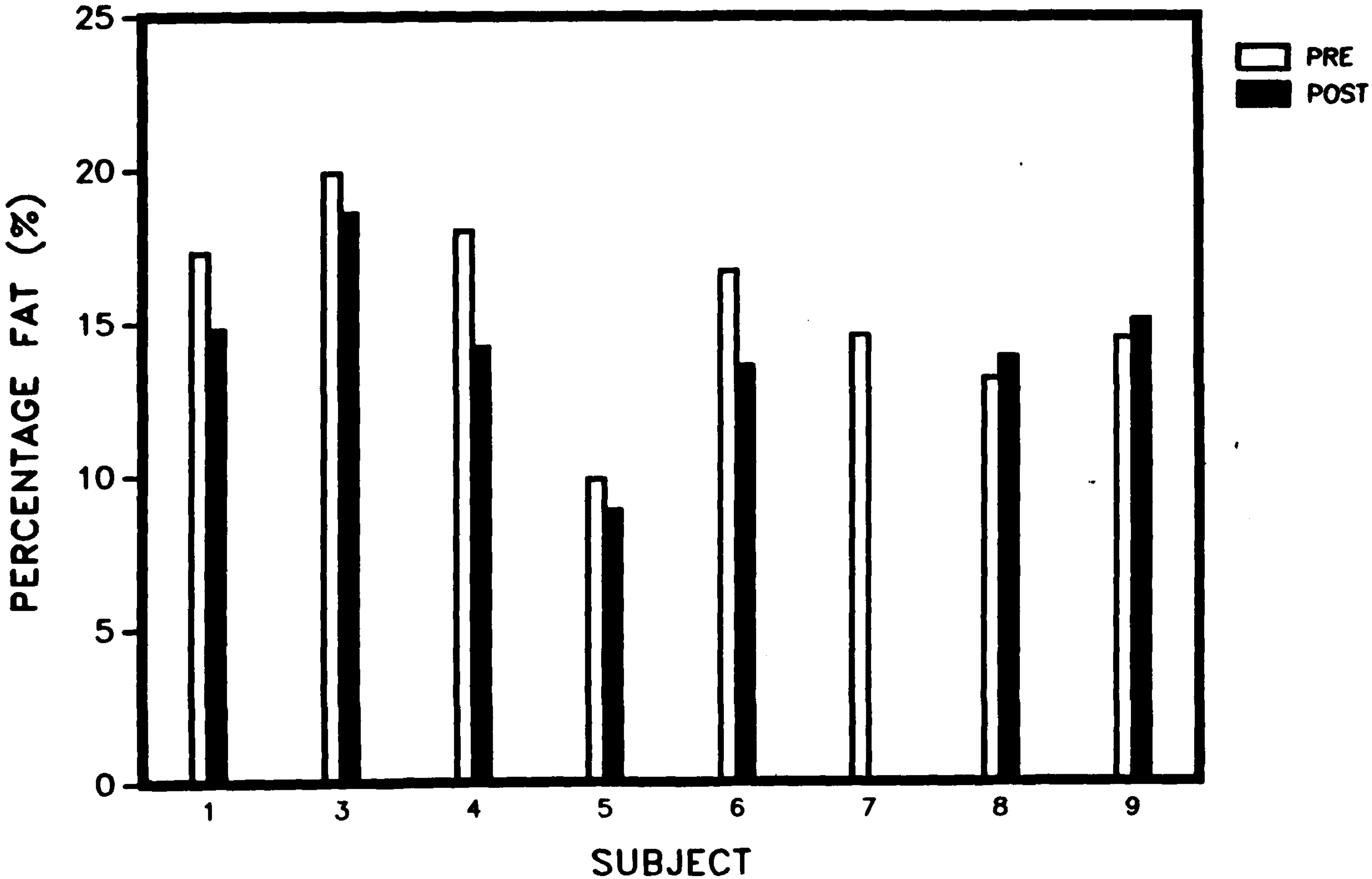

Figure 4

BODY COMPOSITION CHANGES

CT SCAN OF ARM

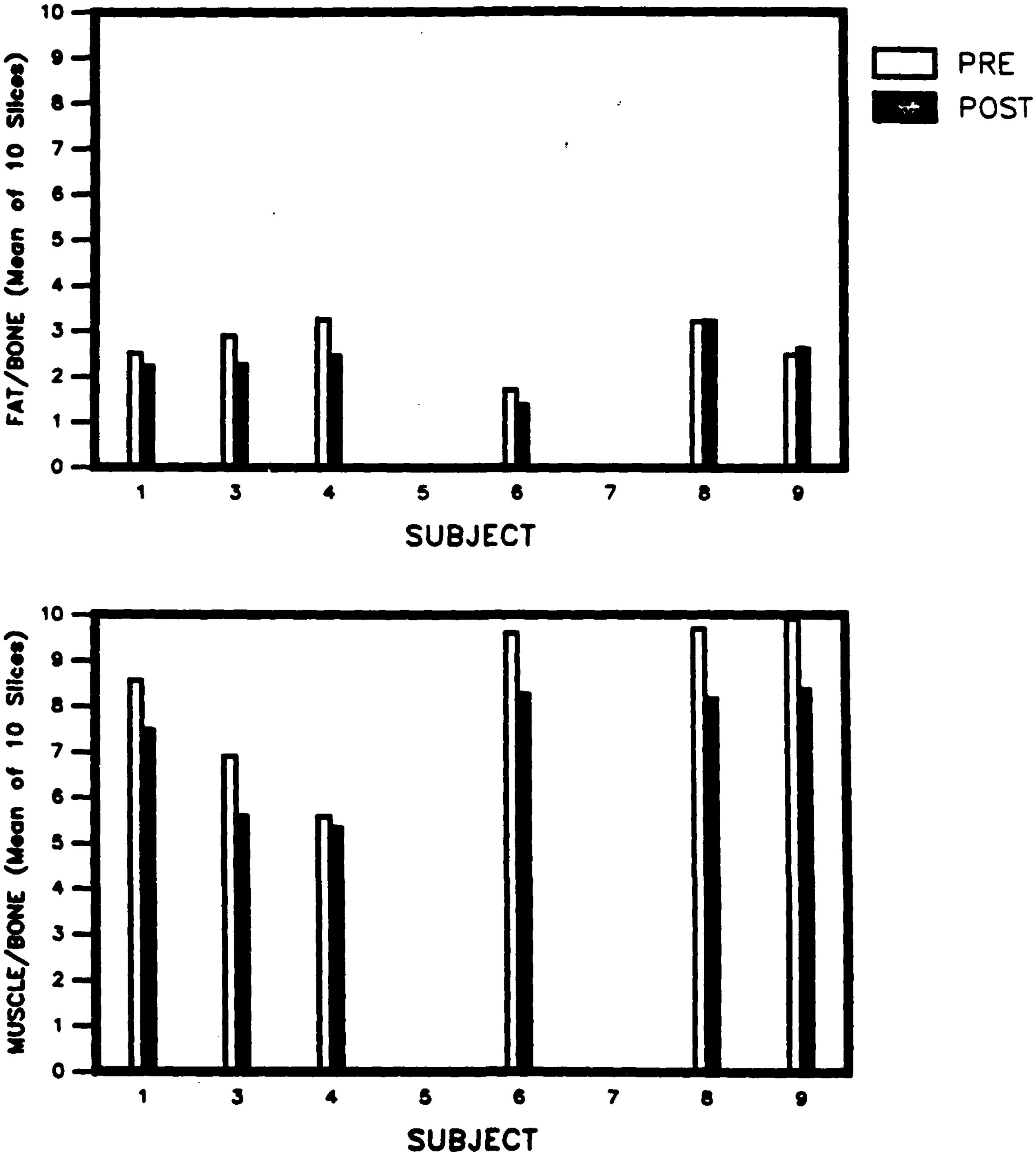

Figure 5
BODY COMPOSITION CHANGES
CT SCAN OF THIGH